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ABSTRACT

This paper discusses the future effects of information technology on libraries and library services, emphasizing the roles of online retrieval systems and electronic processes involving published literature. The following aspects are examined: line charges and terminal costs, a comprehensive electronic journal system, interlibrary loans, electronic publishing via text editing systems, economic constraints, and technological constraints. The focus throughout is on scientific and technical information. Eleven references are cited. (FM)

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ELECTRONIC PUBLISHING AND ITS IMPLICATIONS FOR LIBRARIES

by

Donald W. King

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ELECTRONIC PUBLISHING AND ITS IMPLICATIONS
FOR LIBRARIES

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I'm going to give a talk about technology in libraries that perhaps is somewhat different from what you have heard recently. For one thing, I'm not going to try to emphasize descriptions of very large storage devices, very small storage devices, the speed of computers, or the dramatically decreasing costs. What I will do is try a little crystal ball gazing and predict what is going to happen by the 1990's -- particularly with electronic processes involving published materials.

First, I would like to point out that there is already a great deal of technology used in libraries. A survey conducted by us for the University of Pittsburgh (1), indicates that 84 percent of public libraries have microform collections and equipment, 68 percent have automated circulation systems, 59 percent have computerized cataloging, 42 percent have online systems or terminal access, and 45 percent have other technological aids for service to special clients. Even so, there seems to be some resistance to technology. For example, 42 percent of librarians who were contacted felt that technology advances tend to dehumanize our lives; accordingly, a similar percentage indicated that they went into libraries to work with books and not machines; and 37 percent felt that librarians will not one day be obsolete due to technology. On the other hand, 60 percent indicated that technology gives us more control over the environment; 73 percent see technology as an extension of themselves that enables them to work more effectively; 61 percent do not feel that interpersonal relationships will suffer due to technology; and only 22 percent felt that one day technology would reduce staff in their libraries; and 25 percent would prefer finding materials through the use of card catalogs than with mechanized devices. As you might guess, older librarians tend to be more resistant to new technology than younger ones.

First, I will discuss the future of online retrieval systems and then electronic processes involving the published literature. I do want to state one

caveat which is that any data that I present is limited to scientific and technical information. That is because most of the work leading to the results given below was funded by the National Science Foundation and there were constraints as to the subject areas we investigated.

I mentioned previously that 40 percent of libraries have online systems. There is no question that the amount of use of online systems is growing very rapidly. In 1968, it is estimated there were only about 10,000 searches performed (2). This amount grew very rapidly to about 500,000 in 1973. In 1978, this number was estimated to be about two million, and by 1985 it is estimated to be around four million searches a year (3). If there are in the neighborhood of 40,000 libraries (public, Federal, academic and special), the average number of searches per library would be about 100 per year. We found that only about 10 percent of the scientists (or engineers) in the U.S. use automated bibliographic data bases; whereas, over three times that number use numeric data bases (4). In the journal literature, we estimated that the computer searches were used to identify articles that were read in less than 1 percent of the readings; compared to 25 percent of the read articles that were found through the printed index, 11 percent through cited articles, 18 percent from other persons and 40 percent through browsing the literature. The point is that, even though there is a great deal of online searching taking place, both librarians and scientists are inclined to rely a great deal more on other methods to identify articles that are read.

What can we expect in the future? One way to focus on the future is through a study being conducted by Wilf Lancaster (5). He recently began a Delphi survey which is a survey technique used to find out what experts in a field think will happen in the future. For example, one can speculate whether or not bibliographic services will be completely electronic (that is, completely electronic as opposed to paper-based) and, if so, when that event will occur.

In answer to the survey comment: "For the first time an indexing or abstracting service is discontinued as a print-on-paper publication and is published only electronically," nearly all of the expert respondents indicated that it is technologically feasible. Of the expert respondents, 28 percent said by 1980, 46 percent by 1985, 41 percent by 1990, 5 percent by 1995 and 2 percent said after

the year 2000. (Even though the respondents are experts in the field, it should be mentioned that there is such a system operating right now.) Most of the respondents indicated that they thought that 25 percent of the bibliographic publications would be completely electronic by 1985 or 1990, and most of them felt that by 1995 50 percent of the bibliographic publications would, and after the year 2000, 90 percent would be.

Incidentally, I was a respondent to this particular survey and I seem to be about five to ten years behind the norm or the mode, so that you can see that I am more pessimistic than other experts surveyed in the field. Therefore, you may wish to take that into consideration in judging what I say. I am more pessimistic than many experts for economic reasons rather than technological reasons. Let me give you an example that supports my intuition. When preparing abstracting and indexing publications, there is a very large fixed cost that is associated with the abstracting and the indexing process and preparing tapes or the master images that are used (i.e., for the tapes that can be used for online searching or for the publications). These large costs are incurred whether there is one sale or a million sales of a publication. If all the sales are in publication form, these costs must be covered in the price of the publications. That is why the Chemical Abstracts, for example, is priced around $4500 for a year's publication. The reason that the Chemical Abstracts is much more expensive than most other bibliographic services is that they include chemical compounds which require expensive processes; both from the standpoint of identifying the materials (because they appear in such a broad range of literature) and in handling chemical compounds graphically. The point is that regardless of how many publication sales they have, the large fixed costs must be recovered. If Chemical Abstracts experiences only one sale, the fixed cost for that sale would be in the millions of dollars. If all the sales or uses of the Chemical Abstracts took place online, they would need to cover that large cost as well. Thus, the cost for searches on the bibliographic data bases must be covered by the price being paid for that. Right now, they are not being covered very well; that is, the price for online searches, for the most part, covers mostly the cost that is incurred by the data base producer such as Lockheed, SDC, BRS and the others. You also pay for the line charges; and of course, you pay for your own terminal.

There is no question that the line charges and the terminal costs are likely to come down dramatically. But, as the library services begin to gravitate toward online services, more of the cost of the large input must be covered in the price of the online searches. If libraries begin to cancel their subscriptions to the published data bases in order to perform online searches instead, the price of the searching must increase. This presents a real dilemma. This is a very big problem for the abstracting services. The problem there is that libraries are always faced with a choice of whether or not to purchase an expensive service. But the point is, that the large, fixed costs are going to have to be covered and there's a tradeoff that is made in libraries to decide whether to purchase the published materials or to use online searching (although many of you use both, of course). That tradeoff is partially economic, although it is also based on such factors as convenience to patrons. This means there must be a balance between the price of the online searches published bibliographic product. I believe very strongly that it's desirable to have the capability of doing online searching, but that there is a possibility that the prices are going to go up which will have some impact on the amount of searching that will take place in the future. That is the basic reason that I am a little bit pessimistic concerning the likelihood that searching will be automated in the foreseeable future.

I mentioned previously that I did think that the line charges and the terminal costs are likely to continue down for a number of reasons. One reason is that new technologies will help such as optic fiber and satellites. There is little question that we are going to be able to obtain a broader range of materials through telecommunications at a much less cost. Another factor that will further the reduction in cost is use of intelligent terminals or microcomputers that have the capability of quickly receiving a long message, storing it, cutting off the communication and then printing it out at the leisure of the equipment. One of the current problems is that many of the terminals that are used now require keeping the communication lines open while the terminal prints out a long message. Many libraries are getting equipment for automated circulation, cataloging, and so on that can be used for online searching. Use of this more powerful equipment should reduce the online search cost substantially. As a matter of fact, we estimated that if one employs a 2400 baud terminal, with the ability to capture information, the cost could be reduced to one tenth the current rate.

I think that it is also desirable to have a capability of automatically retrieving full text of materials such as journal articles. This would seem to be a natural extension to online searching. That is, once one has identified needed articles, it would be desirable to be able to push another button and have the full text of articles retrieved; particularly if they are not available in the library.

We now have all the components of a comprehensive electronic journal system. It is possible technologically and even economically. The principal advantage of a comprehensive electronic journal system is that individual articles can be distributed in a manner that is most economically advantageous to them. On the average, there are 2.5 billion copies of articles distributed by publishers every year. There are about ten copies of articles that are distributed by publishers through subscriptions or other means for every one that is read, so that there are some inefficiencies in the sense that there are costs associated with reproducing those unread copies, preparing them for mailing, mailing them, receiving them, the acquisition costs of libraries, and so on. Again, a few articles are frequently read and many infrequently read. If we can find some way to choose or identify the infrequently read articles (where there are thousands of copies sent out for one reading), electronic processing on demand is the most economic form of distribution. As a matter of fact, we find that the break-even point is something about like 50 copies distributed per reading. If the number of readings is less than that, it is cheaper to do it electronically than it is to distribute it in paper form. In other words, if a journal has 10,000 subscribers, it means that every article in that journal is distributed 10,000 times. Now, some of those articles may be read 10,000 times and some may be read 20,000 times; but there may be many articles where there may be only about 10 or 20 readers out of those 10,000 copies distributed. When the latter happens, it may be less expensive to distribute an article electronically than it is to distribute it in paper form.

Another consideration has to do with economic problems again. Two of my colleagues, V. E. Palmour and Robert Wiederkehr (whom some of you may have heard yesterday when he talked about a cost model for cataloging with AACRII) conducted

a library cost model for making decisions concerning whether libraries should purchase subscriptions to journals - as opposed to borrowing copies through interlibrary loans. There are many bases for making that decision; one of which is economic. It does not make much sense to purchase journals if they are never read. The fact that the number of subscriptions to journals by libraries is going up much more slowly than the average number of subscriptions to individuals is a reflection on the fact that people are beginning to recognize this. The question then becomes one of how many readings or how many uses of a journal are necessary to warrant purchasing a copy of that journal - as opposed to relying on interlibrary borrowing. Palmour and Wiederkehr (6) found that the number of uses ranges anywhere from about five to ten readings of a journal. If number of uses is less than that number, then it is less expensive to rely on interlibrary loans. If it is greater than that number, then it is less expensive to purchase it. Data from the University of Pittsburgh study (7) and a study done by Dr. C. C. Chen at MIT (8) show that the distribution of use of journals within a library is very highly skewed. For example, something like 30 percent of the journals have fewer uses than the break-even point. Thus, as much as 30 percent of the journal subscriptions would be cancelled (based on economic considerations alone). This is because it would be cheaper to rely on interlibrary loans than to purchase those journals. If this factor is applied across all libraries, then approximately 30 percent of the journal subscriptions to libraries would be cancelled. We find that something like 35 percent of the subscriptions to journals are library subscriptions, but that is much higher for small journals than for large journals. That is, for journals under 3000 subscriptions, roughly 60 percent of their subscriptions are to libraries and the remainder are to individuals: opposed to large journals like Scientific American or those over 10,000 subscriptions where only about 20 percent of the subscriptions are to libraries rather than to individuals. Thus, if 30 percent of the subscriptions to the small journals are cancelled, the effect is much more devastating than it is to the large ones. Furthermore, we estimated, through our photocopy studies (9) that we did on the new copyright law, that there is a tendency for the small subscription journals to be borrowed more frequently than the large subscription journals. In addition to that, we find that the subscription price to libraries of a small journal is much higher (I believe about $60 for small journals as opposed to about $20 for large journals). This means that the break-even point is higher for the small journals. Thus, there has to be more readings of a small journal in a library to make it economically worthwhile to purchase.

For that reason the proportion of small journals under the breakeven point is even higher than 30 percent; maybe up around 35 or 40 percent.

There will always be a question of the tradeoffs as to whether one purchases a journal and make it available to their patrons or to depend on interlibrary loans, acquisition of individual separates from publishers in the form of reprints or through some electronic means. One of the biggest disadvantages of relying upon an interlibrary loan for getting copies of articles is that there's a large time delay. I think that we estimated the average delay is about two to three weeks. One of the reasons that there is a large time delay is that oftentimes borrowing libraries or a net lending library like Harvard or one of the big university libraries and the journal or article is out or not available for some reason. Then another library must be approached.

There are some electronic systems that are attacking this problem (the MINITEX system in Minnesota is a good example). MINITEX has a TELEX system where libraries can request an interlibrary loan and they can immediately transfer the request to a library in their Minnesota system that has the desired article. The JACS system that NTIS recently started and then aborted was a system that was designed to facilitate this problem.

In view of the economic problems, what is the possibility of a completely paperless form of communication, as far as the scientific and technical journal articles are concerned? The question is, when is this going to happen? Again, I would like to refer to the Delphi study, mentioned earlier (10) as well as the Delphi study that was done for DDC. In answer to the statement--"For the first time a periodical in science and technology will begin to be available in machine-readable form as well as in paper form"; the response from technologists and specialists in the area was that 18 percent felt it would happen by 1980; 49 percent by 1985; 23 percent by 1990; 6 percent by 1995; and 2 percent said it would be after the year 2000. Well, it is already happening with a journal in England. I understand that there is another one in Georgia that is starting. Most of the experts felt that 25 percent of the journals would be in both paper form and electronic form somewhere around the 1990 or 1995 period and that 50 percent of the journals would have both paper and electronic form distribution after 1995; 90 percent felt it would happen after the year 2000; and 40 percent felt that it would never happen, which I thought was very interesting.

In answer to a comment concerning the first time a periodical in science and technology is discontinued on paper publication and is only published electronically; 7 percent said by 1980; 32 percent said by 1985; 35 percent by 1990; 14 percent by 1995; 9 percent after the year 2000; and 2 percent said never. There were also a number of experts who said that 25 percent of the journals would be completely electronic. The proportion of responses were distributed evenly from 1990 to after the year 2000, so there is not a great deal of agreement on that. No one thought that 50 percent of it would occur in the year 2000 or after; again, a number of them thought it would never happen; 49 percent felt that 90 percent of the journals would be completely electronically distributed after the year 2000. The point here is that even though several persons are saying that there is going to be a completely electronic and paperless society, I just don't think it is going to happen; and I think that our findings are very well supported by the feelings expressed by experts in the Delphi survey. The reasons are similar to those expressed earlier concerning complete electronic processing in bibliographic services or publications.

I will give my expectations concerning an electronic alternative to current paper-based publishing (11). Not all publications or articles lend themselves to an electronic alternative because of economic or other factors. We feel that the strongest candidates for an electronic alternative are articles that are infrequently used but are useful for a long time. These articles tend to be found in journals with small circulation and we have sound evidence that such journals are much more likely to encounter economic difficulties in the future than large journals. Thus, there may be ample financial incentive for publishers of these journals to seek an alternative to current practice.

For the most part, the technology specified in an electronic alternative already exists. Most of the technological and economic breakthroughs have occurred outside of scientific and technical communication in areas such as office word processing, telecommunication, technology in non-scientific publication and mass storage. There should be enormous advantages to future scientific and technical communication through use of electronic processes. These advantages stem from more economical and efficient distribution of information.

Electronic word processing and text editing systems have already achieved widespread use. Word processing systems involve editing typewriters that use magnetic digital storage of one form or another. There are also text editing systems that range from terminals that tie into a local computer to intelligent terminals with self-contained memory and microprocessor-based computing functions. These systems yield improvements in editorial quality of manuscripts and provide faster and much more reliable operations. However, their most direct advantage comes from the substantial reduction of secretarial labor costs. Here the cost tradeoff is between increased investment in equipment against reduced labor. Heavy competition in this area is resulting in increased sophistication and flexibility as well as reduced costs. Options such as editing and spelling routines, special print stations, message service and, perhaps most importantly, photocompositor interfaces are available. In the long run, manuscripts will be transmitted to publishers in digital form and articles will be edited and composed by electronic processes, substantially reducing prerun publishing costs.

It has been estimated that general use of terminals will more than double from 1975 to 1980 and by 1990 most handling of business records and correspondence will be electronic. Since many organizations will obtain electronic systems to use for preparation of letters, memoranda, technical reports and so on, the capital investment for purchasing or leasing the equipment should be spread over a broad base and the cost of preparing journal article manuscripts should be lower than with traditional typewriter input. Also, it is possible that library minicomputers, terminals or other equipment could be used by authors, just as libraries now assist authors through online bibliographic search services.

Electronic processes are being used extensively by publishers for editing, redaction and composition. The possibility of direct input from authors to publishers in digital form should increase this potential even more since the cost of keyboarding can be eliminated. Optical character recognition might also be used increasingly for direct input. However, technology and costs of OCR have improved much more slowly than many anticipated. Composition is being increasingly integrated into general text-processing in computer-based systems. As originally designed, these systems were intended primarily for editing text. However, the magnetic digital record can also be stripped of operating codes and input into an electronic composer. This type of integrated system is often used by newspaper publishers.

In the future, publishers will have enormous flexibility in the form and mode of distribution of articles made from master images, that is, formatted article text. Electronic technology has progressed to the point where articles can be individually printed directly from computer output. Impact printers caused problems with this kind of output, but non-impact printing has resolved the problem of computer output speed. The ink-jet, electrophotographic and electrostatic systems all hold substantial promise for scientific and technical publishing.

On the other hand, computer master images can also be transformed into microform or video disks. However, microform has many disadvantages including too many formats, reduction ratios, and retrieval coding schemes; poor quality film images at the reader and with paper form prints; readers which are expensive, hard to use, and bulky; inadequate user environments in libraries; and difficulty in obtaining paper form prints. The new video disk technology also holds some promise for distribution and storage. It is felt that there are some weaknesses here also, since currently their images are not adequate for displaying a full normal-sized printed page on most inexpensive viewing devices. It is felt that the greatest promise for either microform or video disk is with new libraries that wish to inexpensively build up an archival file in certain areas. The problem is that the savings in reproduction (runoff) are not great enough to overcome the large prerun costs. Thus, prices cannot be sufficiently reduced to induce libraries or scientists to purchase these forms of distribution.

One of the areas in which new technology has been directly applicable to scientific and technical communication is in library operations and services. The most prominent of these are online (and offline) bibliographic searches, automated circulation, cataloging of books and interlibrary loan processes. Technology outside of scientific and technical communication that might make the greatest impact on the Preservation function is in mass storage memories. If a National Periodicals System comes into being, one component might be digital storage of articles input directly from publishers. Thus far, the most likely such system is magnetic tape media segmented for mechanical handling. However, there are some output problems associated with queueing delays and the output costs are prohibitively high. Also, other barriers to mass electronic storage are the needs for sophisticated indexing and control and for access software.

The principal electronic processes that could be applied to end-users are output terminals and video displays of one kind or another. End-users can use these devices for full-text retrieval and teleconferences as well as for on-line bibliographic searches which can lead to full-text. The use and success of such electronic processes depends to a large degree on telecommunication costs.

Most telecommunication currently is by voice grade telephone lines. Moreover, value-added networks have provided a potentially low-cost telecommunication capability for all participants in scientific and technical communication. The potential is enhanced by availability of minicomputers or intelligent terminals to senders and receivers which can permit rapid transmittal that will be buffered by this electronic equipment. Also, new technology in long-line communication such as fiber optics and digital transmission and switching equipment could yield substantial decreases in cost. Communication satellites could also be used, but the capital cost of earth stations must be reduced or shared by scientific and technical information users.

The above technological advances, which were developed largely independently of scientific and technical communication, provide all the parts for a comprehensive electronic alternative to paper-based journal publishing. Such a system would provide enormous flexibility. The principal advantage of this flexibility is that individual articles can be distributed in the manner most economically advantageous to them. Highly read articles may still be distributed in paper form, while infrequently read articles can be requested and quickly received by telecommunication when they are needed. Here, the trade-off is that resources formerly wasted in printing, mailing and storage are applied to better identification and retrieval of information which results in reduced cost, better quality and increased efficiency. Other benefits of electronic processing can also be derived. It is felt that better systems integration will yield more emphasis on quality of article content, that fewer articles will be repeated over and over again for updates or for different journals and that the new systems will provide better access and retrieval to information needed in multi-disciplinary research.

In an electronic alternative, articles will be prepared by authors using sophisticated text editing systems. Article preparation may include text writing

jointly through teleconferencing systems in which immediate peer review is possible, comments are made, and specific research questions can be answered. Furthermore, many of the citations used in the article will come from those found in online bibliographic searches. When citations are identified they can be immediately retrieved by telecommunication in full-text on CRT or in paper form. The digital form of the unreviewed manuscript will be directly transmitted electronically to a publisher. The publisher will, in turn, electronically transmit the manuscript to a subject editor who will read the text by CRT or printout and make electronic notes concerning editorial and content quality. The subject editor may choose an appropriate reviewer(s) using a computer program that matches the profile of potential reviewers with the topics covered in the article. Other computer-stored information will also be used to help screen reviewers such as by affiliation and relationship to the authors, status of most recent review, frequency of reviews, timeliness of response of previous reviews and quality of reviews. The reviewers will respond to editors and editors in turn to authors by telecommunication, similar to current teleconferencing processes. Publishers and editors can also use electronic processes for business purposes, address listing, and so on.

An accepted article will then be subject to redaction by text-editing terminal and the computer-based text will be output in several forms, including full text as well as in bibliographic form. The bibliographic form will be transmitted electronically and used directly by search services or input to abstracting and indexing services to be further analyzed and processed. The full text will be sent electronically to some individual scientists designated by the author or by request to scientists based on its topic, author or some other bibliographic identifier. In some instances articles will be telecommunicated through an SDI-like system. The scientists may receive the text on their own personal terminals or on their libraries' terminals. Articles will also be sent directly by telecommunication to a National Periodicals System consisting of a central archive(s) and several decentralized computer stores. The NPS will await telecommunicated requests for copies of articles and will respond with full text telecommunicated to the requestors.

The electronic processes also provide a great deal of flexibility of output which can enhance reading and assimilation of the information. For example,

end-users could request alternative formats of the text that would suit their particular needs, for example for rapid scanning or in-depth reading. Rapid scanning can be facilitated by highlighting certain elements of text, narrowing column widths, widening space between lines and so on. Human factors considerations can also help in-depth reading through other alternative format structures. Electronic processes can also aid in combining mathematical formulae, data presentations and text in a way that meets alternative needs.

The comprehensive electronic alternative system is highly desirable and currently achievable. It is believed that a majority of articles will be handled by at least some electronic processes throughout the Origination, Recording, Preservation, End-use and Transmission functions, but that not all articles will be incorporated into a comprehensive electronic alternative system like that described above. Some articles will be processed electronically in different ways depending on the electronic capabilities of the senders and receivers involved. The various departures from a comprehensive electronic alternative are discussed thoroughly in the three scenario sections that follow.

There are some major constraints in adoption and use of an electronic alternative. One of the principal constraints to alternative communication systems is the lack of incentive to change on the part of the communication participants. For example, authors are said to publish partially for prestige and recognition which results in professional advancement. Certainly, the "publish or perish" environment that exists in some fields of science and in some organizations creates incentive to publish and therefore, any alternative communication system must meet this perceived need. Many publishers lack a financial incentive for drastically deviating from the current journal publishing practices. While many book and small journal publishers appear to have financial problems, most large publishers are doing quite well financially. They make a comfortable margin on income or profits and they require much less capital to publish journals than books since the income from subscriptions is received before most costs are incurred. Therefore, the return on investment for journal publishing is favorable since capital requirements are low and net profit relatively high. Substitution of royalty payments in lieu of subscriptions is going to lessen this advantage some since photocopying takes place on many older publications, and, therefore, the royalty income for these

publications will drag out over time. Thus, any new publishing systems must incorporate some financial incentives or publishers are unlikely to want to change. Another problem is that some income is derived by publishers through sale of advertisements. Distribution of separates appears to obviate use of advertising. However, Whitby (12) has suggested that advertising can be focussed on specific scientists by advertising interest profiles and can then be distributed as separates. This may be much better than current advertising practices.

Scientists as users also present some barriers to new systems that directly impact their behavior. It has been claimed for many years that scientists would quickly adapt to the direct use of computer terminals and would search bibliographic data bases online. However, while some scientists do this, most still rely on an intermediary to perform their searches for them. This is partially because many scientists are without easy access to terminals and partially because some are reluctant to use terminals. Regardless of the reasons, if an alternative journal publishing and distribution system involves direct online communication, some incentives must be provided to scientists and their behavior must be altered. It is believed that, in the future, new scientists who have been trained on terminals in high schools and universities will find it unacceptable to not have these facilities available for analysis, text processing, search and retrieval and other forms of communication.

Libraries have little incentive to change their mode of operating unless their patrons and funders find such change desirable. While many libraries currently are becoming automated for cataloging and internal recordkeeping, they still require motivation to change their procedures in dealing with scientists. Thus, some outside incentive will probably be necessary.

Other constraints are technological. Standards must be set for word processing and text-editing output so that publishers can receive it and easily convert it to the appropriate format. One major problem deals with treating nontextual input, including graphics in forms such as tables, line graphs, photographs, mathematical formulae and chemical compounds. Technologically, graphics can be electronically handled now, but the economics are not practical for the considerable amount of graphics found in articles published in the fields of physical

sciences, engineering and life sciences. Another requirement is that the cost of telecommunication must continue its downward trend in the future. Unfortunately, there is some indication that future Federal Communication Commission rulings could damage this prospect (13). Sending and receiving equipment must be sufficiently sophisticated to permit rapid communication in order to reduce costs. Mass storage devices now available could economically store nearly all current literature, but cost of input and output may be unacceptable unless some breakthroughs in this area are made.

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    Annex I: Communication Functions in Science and Technology.
    Annex II: The Current Practices.
    Annex III: An Electronic Alternative.
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